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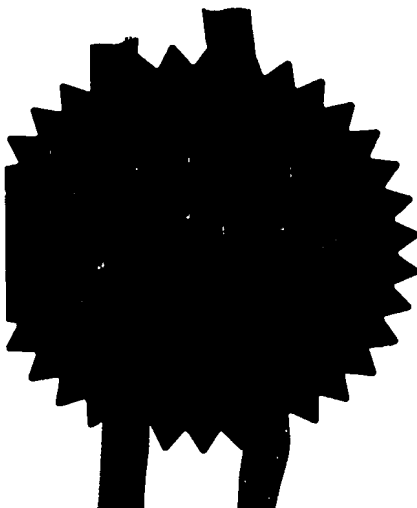
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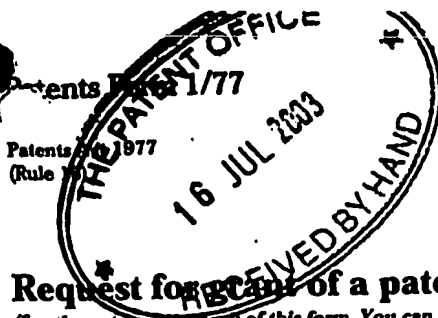
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P01/7700 0.00-0316708.7

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1. Your reference P034827GB

2. Patent application number 0316708.7  
(The Patent Office will fill in this part) 16 JUL 2003

3. Full name, address and postcode of the or of each applicant (underline all surnames)  
DUPONT TEIJIN FILMS U.S. LIMITED PARTNERSHIP  
BUILDING 27  
BARLEY MILL PLAZA  
ROUTES 141 & 48  
WILMINGTON  
DELAWARE 19805  
USA  
Patents ADP number (if you know it) 8544991001  
If the applicant is a corporate body, give the country/state of its incorporation DELAWARE, USA

4. Title of the invention POLYMERIC FILM

5. Name of your agent (if you have one) CARPMAELS & RANSFORD  
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)  
43 BLOOMSBURY SQUARE  
LONDON  
WC1A 2RA

Patents ADP number (if you know it) 83001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number	Country	Priority application number (if you know it)	Date of filing (day / month / year)
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing (day / month / year)
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:  
a) any applicant named in part 3 is not an inventor, or  
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Description 21

Claim(s) 3

Abstract -

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11. I/We request the grant of a patent on the basis of this application.

Signature

Date

*Carpmaels & Ransford*

16 July 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

Dr. B.R. Cockerton

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Carpmaels &amp; Ransford

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**POLYMERIC FILM**

This invention relates to a breathable polymeric film, and a process for the production thereof.

5

Plastic film, particularly polyolefin film, has long been used in the packaging of fresh-cut flowers and vegetables. The primary function of such packaging film is to provide a protective seal against insects, bacteria and air-borne contaminants.

10 Nevertheless, fresh-cut flowers and vegetables have a limited shelf life due to fundamental changes in their biochemistry. Whilst in soil, photosynthesis allows the plant to grow and expire oxygen. However, after harvesting, the plant no longer converts sunlight and carbon dioxide into carbohydrates and oxygen, but uses its stores of carbohydrate to excrete water and carbon dioxide. For plants that are wrapped in plastic packaging, the accumulation of  
15 trapped water in the packaging leads to fungal growths and rotting of the fresh food. Plastic packaging film, particularly polyolefin film, acts as a water barrier and can actually make this situation worse by trapping excreted water within the package. Vegetables having a high moisture content, such as broccoli and mushrooms, are particularly susceptible. It would be desirable to provide packaging which not only provides a barrier to insects,  
20 bacteria and air-borne contaminants but which is also breathable to water (in other words, a film which would allow water to freely pass out of the packaging), thereby increasing the shelf life of the contents by delaying the onset of microbial and fungal growth.

There already exist a number of commercially available breathable films. Several  
25 companies market polyolefin films which have been voided using inorganic fillers thereby allowing easier passage of water. However, such films are not normally transparent and therefore have a disadvantage from a marketing standpoint. Other commercially available films based on thermoplastic elastomers (TPEs) provide excellent breathability but are expensive for packaging applications.

30

Another approach to the manufacture of breathable packaging has been to perforate the film in order to allow egress of excreted gas. The number of perforations per unit area and the perforation diameter may be adjusted depending on the goods to be packaged and the

respiration rate thereof. A film suitable for bread packaging may, for instance, be perforated over its whole surface area with perforations of about 700 microns in diameter. The packaging for goods such as vegetables usually involves a smaller perforation diameter, typically between about 100 to 300 microns, and with fewer perforations per unit area. The disadvantage of this approach is that the perforations expose the packaged goods to insects, bacteria and air-borne contaminants. A further disadvantage, especially for perforated film which has a "tailored" number of holes to allow for gas transmission, is that the water vapour transmission rate of the packaging is not greatly effected by the perforations.

10

It is an object of this invention to provide a breathable, heat-sealable packaging film which allows egress of moisture and excreted gas, particularly moisture, from the packaged product but which provides a physical barrier to insects, bacteria and airborne contaminants, particularly wherein the film is optically clear.

15

According to the present invention, there is provided a breathable, heat-sealable, composite film comprising a perforated polymeric substrate layer having a first and second surface and disposed on the first surface of the substrate layer an unperforated polyester, polyolefin or copolyesterether layer wherein:

- 20 (i) the thickness of the unperforated layer is no more than about 8  $\mu\text{m}$ ; and  
 (ii) the perforated substrate layer has a degree of perforation of from about 0.1 to about 78%, wherein the perforations have an average diameter of between 0.1 and 1.5 mm.

- 25 Preferably, the composite film has a water vapour transmission rate (WVTR) of at least 60  $\text{g/m}^2/\text{day}$ , preferably at least 80  $\text{g/m}^2/\text{day}$ , preferably at least 90  $\text{g/m}^2/\text{day}$  and more preferably at least 100  $\text{g/m}^2/\text{day}$ .

- Preferably, the film has an oxygen transmission rate in the range of about 150 to about 50,000  $\text{cm}^3/\text{m}^2/\text{day}$ , preferably from about 3000 to about 20,000  $\text{cm}^3/\text{m}^2/\text{day}$ , preferably from about 5000 to about 15,000  $\text{cm}^3/\text{m}^2/\text{day}$ .

30

The term "degree of perforation" as used herein refers to the hole fraction of the total surface area expressed as a percentage, i.e. it is the total area of the perforations as a percentage of the total film surface area. Preferably, the degree of perforation is at least 5%, preferably at least 10%, preferably at least 15%, and more preferably at least 20%.

- 5 Preferably the degree of perforation is from about 1 to about 50%, more preferably from about 1 to about 30%.

- Preferably the average perforation diameter is between 0.3 and 1.0 mm, and more preferably between 0.3 and 0.6 mm. Preferably, there are from about 25 to about 400  
10 perforations per  $25 \text{ mm}^2$ , more preferably from about 100 to about 360 perforations per  $25 \text{ mm}^2$ , more preferably from about 150 to 360 perforations per  $25 \text{ mm}^2$ , and more preferably from about 250 to about 360 perforations per  $25 \text{ mm}^2$ .

- The perforated substrate layer may itself be a heat-sealable layer. In a preferred alternative  
15 embodiment, the composite film comprises an additional heat-sealable layer disposed on the second surface of the substrate. The additional heat-sealable layer is also perforated such that the locations of the perforations of the heat-sealable layer correspond to those of the substrate layer. In practice, where the composite film comprises a heat-sealable layer additional to the substrate layer, the perforations in the heat-sealable and substrate layers  
20 are effected at the same time.

- The substrate is a self-supporting film or sheet by which is meant a film or sheet capable of independent existence in the absence of a supporting base. The substrate may be formed from any suitable film-forming material. Thermoplastic polymeric materials are preferred.  
25 Such materials include a homopolymer or copolymer of a 1-olefin, such as ethylene, propylene and but-1-ene, a polyamide, a polycarbonate, PVC, PVA, polyacrylates, celluloses and a polyester. Polyolefins and polyesters, particularly linear polyesters, are preferred. If the composite film does not comprise an additional heat-sealable layer, the substrate is itself heat-sealable. The substrate is preferably uniaxially or biaxially oriented,  
30 preferably biaxially oriented.

Thermoset resin polymeric materials suitable for use as the substrate include addition-polymerisation resins, such as acrylics, vinyls, bis-maleimides and unsaturated polyesters;

formaldehyde condensate resins, such as condensates with urea, melamine or phenols, cyanate resins, functionalised polyesters, polyamides or polyimides.

Suitable polyesters include those derived from one or more dicarboxylic acids, such as  
 5 terephthalic acid, isophthalic acid, phthalic acid, 2,5-, 2,6- or 2,7-naphthalenedicarboxylic acid, succinic acid, sebacic acid, adipic acid, azelaic acid, 4,4'-diphenyldicarboxylic acid, hexahydro-terephthalic acid or 1,2-bis-p-carboxyphenoxyethane (optionally with a monocarboxylic acid, such as pivalic acid), and from one or more glycols, particularly an aliphatic or cycloaliphatic glycol, such as ethylene glycol, 1,3-propanediol, 1,4-butanediol,  
 10 neopentyl glycol and 1,4-cyclohexanedimethanol. An aliphatic glycol is preferred.

A preferred substrate polyester is selected from polyethylene terephthalate and polyethylene naphthalate. Polyethylene terephthalate (PET) or a copolyester thereof is particularly preferred.

15

A preferred polyolefin substrate comprises polyethylene or polypropylene, preferably polypropylene.

In the embodiment wherein the substrate is itself heat-sealable, hereinafter referred to as  
 20 **Embodiment A**, the substrate comprises a heat-sealable polyolefin (preferably a polypropylene) or a heat-sealable polyester.

In the embodiment wherein the composite film comprises an additional heat-sealable layer, hereinafter referred to as **Embodiment B**, the substrate preferably comprises a polyester.  
 25 In Embodiment B, the heat-sealable layer is any layer capable of forming a heat-seal bond to the surfaces of the container, for example a polymeric material such as a polyester, ethylene vinyl alcohol (EVA) or a modified polyethylene. The polymer material of the heat-sealable layer should soften to a sufficient extent that its viscosity becomes low enough to allow adequate wetting for it to adhere to the surface to which it is being  
 30 bonded. In one embodiment, the heat-sealing layer comprises a polyester, particularly a copolyester derived from one or more of the dicarboxylic acid(s) or their lower alkyl diesters with one or more of the glycol(s) referred to herein.

- In one embodiment, hereinafter referred to as **Embodiment B1**, the additional heat-sealable layer comprises a copolyester derived from an aliphatic glycol and at least two dicarboxylic acids, particularly aromatic dicarboxylic acids, preferably terephthalic acid and isophthalic acid. A preferred copolyester is derived from ethylene glycol, terephthalic acid and isophthalic acid. The preferred molar ratios of the terephthalic acid component to the isophthalic acid component are in the range of from 50:50 to 90:10, preferably in the range from 65:35 to 85:15. In a preferred embodiment, this copolyester is a copolyester of ethylene glycol with about 82 mole % terephthalate and about 18 mole % isophthalate.
- 10 In an alternative embodiment, hereinafter referred to as **Embodiment B2**, the additional heat-sealable layer comprises a copolyester derived from an aliphatic diol and a cycloaliphatic diol with one or more, preferably one, dicarboxylic acid(s), preferably an aromatic dicarboxylic acid. Examples include copolyesters of terephthalic acid with an aliphatic diol and a cycloaliphatic diol, especially ethylene glycol and 1,4-cyclohexanedimethanol. The preferred molar ratios of the cycloaliphatic diol to the aliphatic diol are in the range from 10:90 to 60:40, preferably in the range from 20:80 to 40:60, and more preferably from 30:70 to 35:65. In a preferred embodiment this copolyester is a copolyester of terephthalic acid with about 33 mole % 1,4-cyclohexane dimethanol and about 67 mole % ethylene glycol. An example of such a polymer is
- 20 PETG<sup>TM</sup>6763 (Eastman) which comprises a copolyester of terephthalic acid, about 33% 1,4-cyclohexane dimethanol and about 67% ethylene glycol and which is always amorphous. In an alternative embodiment of the invention, the polymer of layer B may comprise butane diol in place of ethylene glycol.
- 25 In a further alternative embodiment, hereinafter referred to as **Embodiment B3**, the additional heat-sealable layer comprises an aromatic dicarboxylic acid and an aliphatic dicarboxylic acid. A preferred aromatic dicarboxylic acid is terephthalic acid. Preferred aliphatic dicarboxylic acids are selected from sebacic acid, adipic acid and azelaic acid. The concentration of the aromatic dicarboxylic acid present in the copolyester is preferably
- 30 in the range from 45 to 80, more preferably 50 to 70, and particularly 55 to 65 mole % based on the dicarboxylic acid components of the copolyester. The concentration of the aliphatic dicarboxylic acid present in the copolyester is preferably in the range from 20 to 55, more preferably 30 to 50, and particularly 35 to 45 mole % based on the dicarboxylic

acid components of the copolyester. Particularly preferred examples of such copolyesters are (i) copolyesters of azeleic acid and terephthalic acid with an aliphatic glycol, preferably ethylene glycol; (ii) copolyesters of adipic acid and terephthalic acid with an aliphatic glycol, preferably ethylene glycol; and (iii) copolyesters of sebacic acid and terephthalic acid with an aliphatic glycol, preferably butylene glycol. Preferred polymers include a copolyester of sebacic acid/terephthalic acid/butylene glycol (preferably having the components in the relative molar ratios of 45-55/55-45/100, more preferably 50/50/100) having a glass transition point ( $T_g$ ) of  $-40^{\circ}\text{C}$  and a melting point ( $T_m$ ) of  $117^{\circ}\text{C}$ , and a copolyester of azeleic acid/terephthalic acid/ethylene glycol (preferably having the components in the relative molar ratios of 40-50/60-50/100, more preferably 45/55/100) having a  $T_g$  of  $-15^{\circ}\text{C}$  and a  $T_m$  of  $150^{\circ}\text{C}$ .

In a further alternative embodiment, hereinafter referred to as **Embodiment B4**, the additional heat-sealable layer comprises an ethylene vinyl acetate (EVA). Suitable EVA polymers may be obtained from DuPont as Elvax<sup>TM</sup> resins. Typically, these resins have a vinyl acetate content in the range of 9% to 40%, and typically 15% to 30%.

The thickness of an additional heat-sealable layer is generally between about 1 and 30% of the thickness of the substrate. Typically, an additional heat-sealable layer may have a thickness of up to about  $25\mu\text{m}$ , more preferably up to about  $15\mu\text{m}$ , more preferably up to about  $10\mu\text{m}$ , more preferably between about 0.5 and  $6\mu\text{m}$ , and more preferably between about 0.5 and  $4\mu\text{m}$ .

Preferably, the composite film exhibits a heat-seal strength to itself of at least 300 g/25mm<sup>2</sup>, preferably from about 400 g/25mm<sup>2</sup> to about 1000 g/25mm<sup>2</sup>, and more preferably from about 500 to about 850 g/25mm<sup>2</sup>.

Formation of the substrate may be effected by conventional techniques well-known in the art. Conveniently, formation of the substrate is effected by extrusion, in accordance with the procedure described below. In general terms the process comprises the steps of extruding a layer of molten polymer, quenching the extrudate and orienting the quenched extrudate in at least one direction.

The substrate may be uniaxially oriented, but is preferably biaxially oriented by drawing in two mutually perpendicular directions in the plane of the film to achieve a satisfactory combination of mechanical and physical properties. Orientation may be effected by any process known in the art for producing an oriented film, for example a tubular or flat film  
5 process.

In the preferred flat film process, the substrate-forming polyester is extruded through a slot die and rapidly quenched upon a chilled casting drum to ensure that the polyester is quenched to the amorphous state. Orientation is then effected by stretching the quenched  
10 extrudate in at least one direction at a temperature above the glass transition temperature of the polyester. Sequential orientation may be effected by stretching a flat, quenched extrudate firstly in one direction, usually the longitudinal direction, i.e. the forward direction through the film stretching machine, and then in the transverse direction. Forward stretching of the extrudate is conveniently effected over a set of rotating rolls or  
15 between two pairs of nip rolls, transverse stretching then being effected in a stenter apparatus. Alternatively, the cast film may be stretched simultaneously in both the forward and transverse directions in a biaxial stenter. Stretching is effected to an extent determined by the nature of the polyester, for example polyethylene terephthalate is usually stretched so that the dimension of the oriented film is from 2 to 5, more preferably 2.5 to 4.5 times  
20 its original dimension in the or each direction of stretching. Typically, stretching is effected at temperatures in the range of 70 to 125°C. Greater draw ratios (for example, up to about 8 times) may be used if orientation in only one direction is required. It is not necessary to stretch equally in the machine and transverse directions although this is preferred if balanced properties are desired.

25

A stretched film may be, and preferably is, dimensionally stabilised by heat-setting under dimensional restraint at a temperature above the glass transition temperature of the polyester but below the melting temperature thereof, to induce crystallisation of the polyester. In applications where film shrinkage is not of significant concern, the film may  
30 be heat set at relatively low temperatures or not at all. On the other hand, as the temperature at which the film is heat set is increased, the tear resistance of the film may change. Thus, the actual heat set temperature and time will vary depending on the composition of the film but should not be selected so as to substantially degrade the tear

resistant properties of the film. Within these constraints, a heat set temperature of about 135° to 250°C is generally desirable, as described in GB-A-838708.

Formation of an additional heat-sealable layer may be effected by conventional techniques.

5 The method of formation of the heat-sealable layer and application thereof to the substrate will depend on the identity of the heat-sealable layer. Conventional techniques include casting the heat-sealable layer onto a preformed substrate layer. Conveniently, formation of an additional heat-sealable layer and the substrate is effected by coextrusion, which would be suitable for Embodiments B1 and B2 above. Other methods of forming the heat-  
10 sealable layer include coating the heat-sealable polymer onto the substrate, and this technique would be suitable for Embodiments B3 and B4 above. Coating may be effected using any suitable coating technique, including gravure roll coating, reverse roll coating, dip coating, bead coating, extrusion-coating, melt-coating or electrostatic spray coating. Coating may be conducted "off-line", i.e. after any stretching and subsequent heat-setting  
15 employed during manufacture of the substrate, or "in-line", i.e. wherein the coating step takes place before, during or between any stretching operation(s) employed. Preferably, coating is performed in-line, and preferably between the forward and sideways stretches of a biaxial stretching operation ("inter-draw" coating). Examples of the coating of heat-sealable layers include: GB-2024715 and GB-1077813 which disclose the inter-draw  
20 extrusion-coating of polyolefin onto substrates of polyolefin and polyester respectively; US-4333968 which discloses the inter-draw extrusion-coating of an ethylene-vinyl acetate copolymer onto a polypropylene substrate; and WO-02/59186 which discloses the coating of copolyester, and the disclosures of these documents are incorporated herein by  
reference.

25

Prior to application of an additional heat-sealable layer onto the substrate, the exposed surface of the substrate may, if desired, be subjected to a chemical or physical surface-modifying treatment to improve the bond between that surface and the subsequently applied layer. For example, the exposed surface of the substrate may be subjected to a  
30 high voltage electrical stress accompanied by corona discharge. Alternatively, the substrate may be pretreated with an agent known in the art to have a solvent or swelling action on the substrate, such as a halogenated phenol dissolved in a common organic

solvent e.g. a solution of p-chloro-m-cresol, 2,4-dichlorophenol, 2,4,5- or 2,4,6-trichlorophenol or 4-chlororesorcinol in acetone or methanol.

The substrate is suitably of a thickness between about 5 and 350 $\mu$ m, preferably from 9 to about 150 $\mu$ m and particularly from about 12 to about 40 $\mu$ m.

Perforation of the substrate and, if present, the additional heat-sealable layer may be effected using an Intermittent Hot Needle Perforator (PX9 series; BPM Engineering Services Ltd, Rochdale, UK). Any suitable arrangement for the hole pattern may be adopted. For instance, the holes may be arranged in a cubic close-packed arrangement or a hexagonal close-packed arrangement. Preferably all perforations have the same or substantially the same diameter.

The unperforated polyester layer is preferably a synthetic linear polyester selected from those mentioned herein above, particularly a polyester derived from one dicarboxylic acid, preferably an aromatic dicarboxylic acid, preferably terephthalic acid or naphthalenedicarboxylic acid, more preferably terephthalic acid, and one glycol, particularly an aliphatic or cycloaliphatic glycol, preferably ethylene glycol. Preferably, the unperforated polyester layer comprises PET.

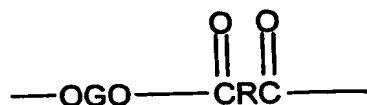
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The unperforated layer may also be a polyolefin, for instance polyethylene, polystyrene (including oriented polystyrene) or polypropylene (including oriented polypropylene).

The unperforated layer may also comprise a copolyesterether, for instance as described in US-4,725,481, the disclosure of which copolyesterethers is incorporated herein by reference.

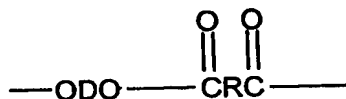
In a preferred embodiment, the copolyetherester elastomer(s) have a multiplicity of recurring long-chain ester units and short-chain ester units joined head-to-tail through ester linkages, said long-chain ester units being represented by the formula:

30



(I)

and said short-chain ester units being represented by the formula:



(II)

wherein

G is a divalent radical remaining after the removal of terminal hydroxyl groups from a poly(alkylene oxide)glycol having an average molecular weight of about 400-3500,

10 wherein the amount of ethylene oxide groups incorporated in said one or more copolyetheresters by the poly(alkylene oxide)glycol is from about 20 to about 68 weight percent, preferably from about 25 to about 68 weight percent, based upon the total weight of the copolyetherester(s);

R is a divalent radical remaining after removal of carboxyl groups from a dicarboxylic acid

15 having a molecular weight less than about 300;

D is a divalent radical remaining after removal of hydroxyl groups from a diol having a molecular weight less than about 250;

wherein said copolyetherester(s) contain from about 25 to about 80 weight percent short-chain ester units.

20

In one embodiment, the unperforated layer is a polyester or copolyetherester.

The unperforated layer may itself be uniaxially or biaxially oriented, as described herein.

It will be understood that where a lamination technique is used to make the composite film,

25 the self-supporting unperforated film may be manufactured by the film production methods described generally herein.

The thickness of the unperforated polyester layer is preferably no more than about 5  $\mu\text{m}$ , preferably no more than 3  $\mu\text{m}$ , preferably no more than 1.5  $\mu\text{m}$ , more preferably no more than 1.0  $\mu\text{m}$ . Typically, the thickness is 0.5  $\mu\text{m}$  or greater.

- 5 The composite film comprising the perforated and unperforated layers may be formed by any suitable technique, for instance by extrusion-coating, melt-coating or lamination of the unperforated layer onto the perforated substrate (or onto the perforated substrate and heat-sealable layer composite). The extrusion-coating, melt-coating or lamination step may be performed according to conventional techniques well-known in the art.

10

Extrusion-coating is described by K.A. Mainstone in *Modern Plastics Encyclopedia*, 1983-84, Vol. 60, No. 10A, Edition 1, pp195-198 (McGraw-Hill, NY) and also by Franz Durst and Hans-Günther Wagner in *Liquid Film Coating* (Chapman and Hall; 1997; Eds S.F. Kistler and P.M. Schweizer; Chapter 11a). The extrusion-coating process is generally used  
 15 for polymers of medium or high viscosity (at least 50 Pa.s and up to about 5000 Pa.s) and generally employs an air-gap (typically about 15cm) between the die and the substrate. The coated substrate is passed between a heat-removing chill roller and a pressure-loaded resiliently-covered nip-roll. Typically, an extrusion-coating process is performed at a temperature of at least 300°C and often higher.

20

- Melt-coating, also known as hot melt-coating or slot-coating, is described by Durst and Wagner (*ibid*). The coating is generally conducted at a temperature of about 260°C or below (typically 200 to 260°C, particularly 220 to 250°C, and more particularly 230 to 250°C). Melt-coating equipment typically comprises a melter, coupled to a die via an  
 25 insulated flexible hose. The melter consists of a hopper having heating elements at its base, which heat the polymer/adhesive to a molten state. The hopper is fed continuously by conventional means so that the melter is always "topped up", thereby minimising air ingress to the molten polymer to reduce oxidation of the molten polymer. The molten polymer is then pumped through the hose to a traditional "coathanger" die. In the  
 30 traditional melt-coating process, the substrate web is pressed up against the die by a roller such that there is no air gap between the die and substrate. The roller is generally a rubber-backing roller which provides sufficient back-pressure to the die to provide an even coating layer. The viscosity of the molten coating liquid at the point of application to the

substrate must not be too high otherwise the polymer will not flow properly, resulting in difficulties in coating and uneven coat thicknesses, but should not be too low that the coating liquid passes through the perforations of the substrate layer. Preferably the viscosity of the coating layer polymer at the processing temperature is no more than about 5 50 Pa.s and preferably at least about 20 Pa.s.

A lamination process should be conducted such that the important characteristics of the film are retained. If the adhesive layer is too thick, it may form a barrier to the passage of water vapour through the film and the perforations may become blocked, resulting in a 10 lower WVTR. Accordingly, a lamination step should use only a minimum of adhesive. The composite film of the present invention requires only a low delamination resistance for suitability in its primary intended application, i.e. breathable packaging film. Typically, the delamination bond strength of the composite film is no more than  $300 \text{ g/25mm}^2$ , preferably from about  $100 \text{ g/25mm}^2$  to about  $300 \text{ g/25mm}^2$ , and more preferably from about 150 to 15 about  $300 \text{ g/25mm}^2$ . Preferably, therefore, the adhesive is applied at a coat weight of no more than  $2.0 \text{ g/m}^2$ , preferably no more than  $0.5 \text{ g/m}^2$ , and preferably no more than  $1.0 \text{ g/m}^2$ .

In a preferred embodiment, the adhesive comprises an EVA, and is preferably a fast-setting 20 adhesive, for instance BAM301 (Beardow and Adams Ltd, Milton Keynes, UK), which has a typical setting time of between 1 and 2 seconds.

In a preferred embodiment, the adhesive is applied to the unperforated polyester film or the perforated substrate, preferably the unperforated film, using a conventional spray melt- 25 coating technique. Spray melt-coating equipment (Dynafibre<sup>TM</sup>) is obtainable from Mercers Ltd (Rugby, UK; a licensee of ITW Dynatech Inc, USA).

Lamination is then conveniently effected by passing the coated, unperforated film and the perforated substrate through a heated nip-roller to obtain the final composite film. Other 30 methods and equipment suitable for effecting lamination will be apparent to the skilled person.

Prior to application of the adhesive and lamination, the exposed surface of the perforated and unperforated layers of the composite film may, if desired, be subjected to a chemical or physical surface-modifying treatment as described hereinabove.

- 5 According to a further aspect of the present invention, there is provided a process for producing a breathable, heat-sealable composite film comprising
- (a) providing a polymeric substrate layer having a first and second surface and optionally a discrete heat-sealable layer disposed on the second surface of the substrate;
  - 10 (b) perforating said substrate and if present said discrete heat-sealable layer; and
  - (c) providing an unperforated polyester, polyolefin or copolyesterether layer on the first surface of the substrate,
- wherein
- (i) the thickness of the unperforated layer is no more than 8  $\mu\text{m}$ ; and
  - 15 (ii) the perforated substrate layer has a degree of perforation of from about 0.1 to about 78%, wherein the perforations have an average diameter of between 0.1 and 1.5 mm.

In a preferred embodiment, the process comprises laminating the unperforated layer onto  
20 the substrate wherein the lamination step comprises the steps of spray melt-coating an adhesive onto the unperforated film or the perforated substrate, preferably the unperforated film, and contacting the unperforated and perforated layer to effect lamination.

One or more of the layers of the polymeric film may conveniently contain any of the  
25 additives conventionally employed in the manufacture of polymeric films. Thus, agents such as cross-linking agents, dyes, pigments, voiding agents, lubricants, anti-oxidants, radical scavengers, UV absorbers, thermal stabilisers, anti-blocking agents, surface active agents, slip aids, optical brighteners, gloss improvers, prodegradents, viscosity modifiers and dispersion stabilisers may be incorporated as appropriate. In particular the composite  
30 film may comprise a particulate filler which may, for example, be a particulate inorganic filler or an incompatible resin filler or a mixture of two or more such fillers. Such fillers are well-known in the art.

Particulate inorganic fillers include conventional inorganic fillers, and particularly metal or metalloid oxides, such as alumina, silica (especially precipitated or diatomaceous silica and silica gels) and titania, calcined china clay and alkaline metal salts, such as the carbonates and sulphates of calcium and barium. The particulate inorganic fillers may be of the voiding or non-voiding type. Suitable particulate inorganic fillers may be homogeneous and consist essentially of a single filler material or compound, such as titanium dioxide or barium sulphate alone. Alternatively, at least a proportion of the filler may be heterogeneous, the primary filler material being associated with an additional modifying component. For example, the primary filler particle may be treated with a surface modifier, such as a pigment, soap, surfactant coupling agent or other modifier to promote or alter the degree to which the filler is compatible with the polymer layer. Preferred particulate inorganic fillers include titanium dioxide and silica.

The inorganic filler should be finely-divided, and the volume distributed median particle diameter (equivalent spherical diameter corresponding to 50% of the volume of all the particles, read on the cumulative distribution curve relating volume % to the diameter of the particles - often referred to as the "D(v,0.5)" value) thereof is preferably in the range from 0.01 to 5  $\mu\text{m}$ , more preferably 0.05 to 1.5  $\mu\text{m}$ , and particularly 0.15 to 1.2  $\mu\text{m}$ . Preferably at least 90%, more preferably at least 95% by volume of the inorganic filler particles are within the range of the volume distributed median particle diameter  $\pm 0.8 \mu\text{m}$ , and particularly  $\pm 0.5 \mu\text{m}$ . Particle size of the filler particles may be measured by electron microscope, coulter counter, sedimentation analysis and static or dynamic light scattering. Techniques based on laser light diffraction are preferred. The median particle size may be determined by plotting a cumulative distribution curve representing the percentage of particle volume below chosen particle sizes and measuring the 50th percentile.

The components of the composition of a layer may be mixed together in a conventional manner. For example, by mixing with the monomeric reactants from which the layer polymer is derived, or the components may be mixed with the polymer by tumble or dry blending or by compounding in an extruder, followed by cooling and, usually, comminution into granules or chips. Masterbatching technology may also be employed.

In the preferred embodiment, the film of the present invention is optically clear, preferably having a % of scattered visible light (haze) of <10%, preferably <6%, more preferably <3.5 % and particularly <2%, measured according to the standard ASTM D 1003. Preferably, the total light transmission (TLT) in the range of 400-800 nm is at least 75%, preferably at least 80%, and more preferably at least 85%, measured according to the standard ASTM D 1003. In this embodiment, filler is typically present in only small amounts, generally not exceeding 0.5% and preferably less than 0.2% by weight of the polymer of a given layer.

The primary use of the film of the present invention is as a breathable film for packaging freshly cut flowers, vegetables fruit and salads. The film may make up all or substantially all of the packaging for such products, or may comprise only part of the total packaging. For instance, the film may form a heat-sealed lid onto a receptacle in or on which the goods are disposed. The receptacle may be a tray such as a thermoformed tray or bowl, and may, for instance be formed of polyester, such as polyethylene terephthalate, or of polypropylene, polystyrene, or may be PVDC-coated. A film according to the invention is particularly suitable for use as a lid on a container made from, for instance, polyester, polystyrene or polypropylene. Sealing of the container is effected by techniques well-known to those skilled in the art. Once the contents to be packaged have been introduced into the container, the heat-sealable film lid is placed upon the container such that the heat-sealable layer of the film is in contact with the container, and is affixed using temperature and/or pressure using conventional techniques and equipment. In an alternative embodiment, the film is heat-sealed to itself to form substantially all of the packaging.

In an alternative embodiment, the polymeric film of the invention may also be used for sealing or providing a lid on a container for packaging convenience foods, for example ready-prepared meals which are warmed either in a microwave or a conventional oven. During the cooking cycle, water vapour is driven from the food. The breathable film of the present invention allows the steam produced during the cooking cycle to be vented from the container. This avoids the build-up of pressure within the container and the risk of rupture of the film lid, which can cause fragments of the film lid to contaminate the contents of the container. Conventional film lids for ovenable ready-prepared food containers generally required that the user pierce the lid to prevent this. However, the need for piercing the lid prior to warming the food in its container is often forgotten or not

understood by the user. The self-venting breathable films of the present invention are also advantageous in that they promote uniform heating over the whole volume of the foodstuff, which can be a problem with existing lids for these types of applications. The container may be an APET/CPET tray (a composite material having an amorphous polyethylene terephthalate layer on top of a crystalline polyethylene terephthalate layer). Other suitable types of container include a foil tray (particularly an aluminium foil tray), a metallised tray and a tray formed from PET-coated cartonboard or paperboard. Of particular utility are trays formed from metallised (particularly flash-metallised) PET cartonboard. For example, the tray may be produced from PET which has been metallised to an optical density in the range of about 0.01 to 4.0 and which is laminated to cartonboard. In one embodiment, the tray is a susceptor tray made from materials such as those disclosed in GB-A-2280342, EP-A-0563442 or GB-A-2250408, or is a susceptor tray produced in accordance with the disclosures of these documents, which are incorporated herein by reference. Desirably, the heat-seal strength when sealed to a standard APET/CPET tray is in the range of 300 to 1800g/25mm<sup>2</sup>, measured as described herein. It is preferred that the heat seal strength is at least 400, preferably at least 600, preferably at least 700 and more preferably at least 800g/25mm<sup>2</sup> when sealed to a standard APET/CPET tray. Preferably, the heat-seal strength of the coated film to APET/CPET trays is in the range of 800-1500g/25mm<sup>2</sup>, preferably 800-1200 g/25mm<sup>2</sup>.

20

Sealing of the container is effected by techniques well-known to those skilled in the art. Once the contents to be packaged have been introduced into the container, the heat-sealable film lid is placed upon the container such that the heat-sealable layer of the film is in contact with the container, and is affixed using temperature and/or pressure using conventional techniques and equipment.

25

In a further aspect, the invention provides a sealed container comprising a receptacle containing flowers or food substance, and a lid formed from a polymeric film as defined herein.

30

The following test methods may be used to characterise the polymeric film:

- (i) the clarity of the film may be evaluated by measuring total light transmission (TLT) and haze (% of scattered transmitted visible light) through the total thickness of the film using a Gardner XL 211 hazemeter in accordance with ASTM D-1003-61.
- 5 (ii) Heat-seal strength of the heat-sealable layer to itself is measured by positioning together and heating the heat-sealable layers of two samples of polyester film at 140°C for one second under a pressure of 275 kPa (40 psi). The sealed film is cooled to room temperature, and the heat-seal strength determined by measuring the force required under linear tension per unit width of seal to peel the layers of the film apart at a constant speed of 4.23 mm/second.
- 10 (iii) Heat-seal strength to a standard APET/CPET tray is measured by the following procedure. The coated film was sealed, by means of the coating layer, to a standard APET/CPET tray using a Microseal PA 201 (Packaging Automation Ltd, England) tray sealer at a temperature of 180°C, and pressure of 80 psi for one second. Strips of the sealed film and tray were cut out at 90° to the seal, and the load required to pull the seal apart was measured using an Instron Model 4301 operating at a crosshead speed of 0.2 mmmin<sup>-1</sup>. The procedure was repeated and a mean value of 5 results calculated.
- 15 (iv) Delamination Bond Strength was measured by the following procedure. Using a straight edge and a calibrated sample cutter (25mm+/-0.5mm) five strips of laminate of minimum length 100mm were cut. Peel between the laminated layers was initiated at one end of each sample and the laminates peeled apart over a distance of approximately 40mm in length. Each sample in turn was tested using an Instron model 4464 materials test machine, using pneumatic action grips with rubber jaw faces. Crosshead speed was 50mm/min<sup>-1</sup>. The samples were inserted into the Instron jaws with one layer clamped in the fixed jaws and the other half in the moving jaws ensuring that an equal amount of each layer was held in each jaw to allow the laminate to be pulled apart evenly. The equipment recorded the mean peel strength of each sample between 10mm and 50mm and the bond strength of the laminate was quoted as an average of 5 samples in g/25mm.
- 20 25 (v) Water vapour transmission rates were measured using a Lyssy Water Vapour Permeation Tester model number L80 400J. Test samples were prepared by cutting around a template (100x110mm). Once cut to size samples were sealed into a
- 30

standard Lyssy sample holder card by placing in a hydraulic press for approximately 5 minutes at a pressure of 2 tonnes.

5 Prior to testing the equipment was calibrated using standard 19micron and 36micron PET film (Melinex<sup>®</sup> S; DuPont Teijin Films; m.p. 248°C; relative density at 23°C of 1.40). In order to keep the conditioning and measuring chambers apart an impermeable foil laminate was used in between testing of samples. During sample changeover the test specimen and the foil layer were placed on top of each other to ensure that at no time the measuring chamber was directly exposed to the conditioning chamber.

10 Testing was carried out at a temperature of 38°C and at 90% relative humidity. Equilibrium was reached when consecutive results change by less than 2% indicated by an asterisk on the equipment printout. Water vapour transmission rate quoted in g/m<sup>2</sup>/day is recorded when 5 consecutive asterisks were seen on the printout.

15 (vi) Oxygen Transmission Rates were determined using conventional techniques in a Mocon 1050 (Modern Controls Inc.) test instrument. A sample of the film was placed in the machine with the nitrogen carrier gas (containing 1% hydrogen) flowing both above and below the sheet, in order that a background reading can be obtained. The nitrogen above the sheet was replaced by oxygen, and the amount of  
20 oxygen able to permeate through the sheet was measured in a carrier gas by using a sensor.

The invention is illustrated by reference to Figures 1 and 2 wherein:

25 Figure 1 shows a breathable film (1) having an unperforated polyester layer (2) and a perforated substrate layer (3).

Figure 2 shows a breathable film (1) having an unperforated polyester layer (2), a perforated substrate layer (3) and a perforated heat-sealable layer (4).

30

The invention is further illustrated by the following examples. It will be appreciated that the examples are for illustrative purposes only and are not intended to limit the invention

as described above. Modification of detail may be made without departing from the scope of the invention.

### **EXAMPLES**

#### **5 Comparative Example 1**

A commercially available gas permeable OPP (Danisco™ 35PA-180) of thickness 35  $\mu\text{m}$  and having 180 perforations per  $\text{m}^2$  of diameter 125  $\mu\text{m}$  was analysed for its WVTR in a region having a single perforation and in a non-perforated region. The results are in Table 1.

10

#### **Comparative Example 2**

The analysis of Comparative Example 1 was repeated for Danisco™ 35PA-260 gas permeable film of thickness 35  $\mu\text{m}$  and having 260 perforations per  $\text{m}^2$  of diameter 250  $\mu\text{m}$ . The results are in Table 1.

15

**Table 1**

FILM	FILM REGION	WVTR/ $\text{g}/\text{m}^2/\text{day}$
Comparative Example 1	non-perforated region	1.39
	perforated region	3.42
Comparative Example 2	non-perforated region	1.39
	perforated region	6.44

The data in table 1 demonstrate that in the area of a perforation, the WVTR of a perforated film is of the same order of magnitude as an unperforated film. In addition, for the two films tested, an increase in the number of perforations of almost 50% coupled with a two-fold increase in perforation diameter, only produces a less than two-fold increase in WVTR. Thus, not only is perforated mono-layer oriented polypropylene film not breathable in terms of water vapour transmission, the perforations provide little effect.

#### **25 Example 1**

A polymer composition comprising polyethylene terephthalate was melt-extruded, cast onto a cooled rotating drum and stretched in the direction of extrusion to approximately 3 times its original dimensions. The film was passed into a stenter oven at a temperature of

100°C where the film was stretched in the sideways direction to approximately 3 times its original dimensions. The biaxially stretched film was heat-set at a temperature of about 230°C by conventional means. The total thickness of the final film was 3µm. The film was a clear film with a haze of 5%. The WVTR of the film was measured as 104 g/m<sup>2</sup>/day.

5

A clear biaxially oriented heat-sealable polypropylene film (UCB Films, Wigton, UK) of thickness 20 µm was perforated using the equipment herein described to give 360 perforations/25 mm<sup>2</sup> having an average diameter of 0.7 µm.

The polyester film was spray melt-coated with EVA adhesive (BAM301, Beardow & Adams Ltd, Milton Keynes, UK) at a coat-weight of 1.5 g/m<sup>2</sup> in accordance with the procedure described herein and then laminated to the perforated polypropylene film by passing the two films through a heated nip-roller. The WVTR of the final film was 94 g/m<sup>2</sup>/day.

#### 15 Example 2

The procedure of Example 1 was repeated except that the unperforated polyester film was 1.2 µm in thickness. The WVTR of the final laminated film was 240 g/m<sup>2</sup>/day.

#### Example 3

20 The procedure of Example 1 was repeated except that the polypropylene film was replaced with a bi-layer polyester film comprising a substrate layer of clear polyethylene terephthalate and a copolyester heat-sealable layer, prepared as follows:

A polymer composition comprising polyethylene terephthalate was extruded and cast onto a cooled rotating drum and stretched in the direction of extrusion to approximately 3 times its original dimensions. The film was passed into a stenter oven at a temperature of 100°C where the film was stretched in the sideways direction to approximately 3 times its original dimensions. The biaxially stretched film was heat-set at about 230°C by conventional means. The heat-set film was then coated off-line using conventional coating means with a copolyester of azeleic acid/terephthalic acid/ethylene glycol (45/55/100) to give a dry coating thickness of 2 µm. The total film thickness was 25 µm.

The WVTR of the final laminated film was 78 g/m<sup>2</sup>/day.

**Example 4**

The procedure of Example 1 was repeated except that the polypropylene film was replaced with a bi-layer polyester film comprising a substrate layer of clear polyethylene terephthalate and a copolyester heat-sealable layer, prepared as follows:

- 5 A polymer composition comprising polyethylene terephthalate was co-extruded with a copolyester comprising terephthalic acid/isophthalic acid/ethylene glycol (82/18/100), cast onto a cooled rotating drum and stretched in the direction of extrusion to approximately 3 times its original dimensions. The film was passed into a stenter oven at a temperature of 100°C where the film was stretched in the sideways direction to approximately 3 times its
- 10 original dimensions. The biaxially-stretched film was heat-set at a temperature of about 230°C by conventional means. The total thickness of the final film was 23  $\mu\text{m}$ ; the heat sealable layer was approximately 4  $\mu\text{m}$  thick.

## CLAIMS

1. A breathable, heat-sealable, composite film comprising a perforated polymeric substrate layer having a first and second surface and disposed on the first surface of the substrate layer an unperforated polyester, polyolefin or copolyesterether layer wherein:
  - 5 (i) the thickness of the unperforated layer is no more than about 8  $\mu\text{m}$ ; and
  - (ii) the perforated substrate layer has a degree of perforation of from about 0.1 to about 78%, wherein the perforations have an average diameter of between 0.1 and 1.5 mm.
- 10 2. A film according to claim 1 wherein the thickness of the unperforated layer is no more than 5  $\mu\text{m}$ .
3. A film according to claim 1 wherein the thickness of the unperforated layer is no more than 3  $\mu\text{m}$ .
- 15 4. A film according to any preceding claim wherein the perforated substrate layer has between 25 and 400 perforations/ $25\text{mm}^2$ .
5. A film according to any preceding claim wherein the average perforation diameter
  - 20 is 0.3 to 1.0 mm.
6. A film according to any preceding claim wherein the degree of perforation is from about 10 to about 50%.
- 25 7. A film according to any of claims 1 to 6 wherein the substrate layer is a heat-sealable layer.
8. A film according to claim 7 wherein the substrate layer is a polyolefin.
- 30 9. A film according to any of claims 1 to 7 wherein the substrate comprises polyester.
10. A film according to claim 9 wherein the substrate comprises polyethylene terephthalate.

11. A film according to any preceding claim wherein there is disposed on the second surface of the substrate layer a perforated heat-sealable layer.

12. A film according to claim 11 wherein the heat-sealable layer is a copolyester  
5 derived from ethylene glycol, terephthalic acid and isophthalic acid, preferably wherein the molar ratio of the terephthalic acid component to the isophthalic acid component is in the range from 65:35 to 85:15, and more preferably is about 82:18.

13. A film according to claim 11 wherein the heat-sealable layer is a copolyester  
10 derived from terephthalic acid, ethylene glycol and 1,4-cyclohexanedimethanol, preferably wherein the molar ratio of 1,4-cyclohexanedimethanol to ethylene glycol is in the range from 30:70 to 35:65, and more preferably is about 33:67

14. A film according to claim 11 wherein the heat-sealable layer is a copolyester  
15 derived from an aromatic dicarboxylic acid, an aliphatic dicarboxylic acid and a stoichiometric amount of one or more glycols, wherein the concentration of said aromatic dicarboxylic acid in the copolyester is in the range from 50 to 55 mole % based on all the dicarboxylic acid components of the copolyester, and the concentration of said aliphatic dicarboxylic acid in the copolyester is in the range from 45 to 50 mole % based on all the  
20 dicarboxylic acid components of the copolyester.

15. A film according to claim 14 wherein said aromatic dicarboxylic acid is terephthalic acid, wherein said aliphatic dicarboxylic acids are selected from sebacic acid, adipic acid and azelaic acid, and wherein the glycol component is ethylene or butylene  
25 glycol.

16. A film according to any preceding claim wherein the film exhibits a haze of less than 6%.

30 17. A film according to any preceding claim wherein the film exhibits a total light transmission of at least 80%.

18. A process for producing a breathable, heat-sealable composite film comprising

- (a) providing a polymeric substrate layer having a first and second surface and optionally a discrete heat-sealable layer disposed on the second surface of the substrate;
- (b) perforating said substrate and if present said discrete heat-sealable layer; and
- (c) providing an unperforated polyester, polyolefin or copolyesterether layer on a first surface of the substrate,

wherein

- (i) the thickness of the unperforated layer is no more than 8  $\mu\text{m}$ ; and
- (ii) the perforated substrate layer has a degree of perforation of from about 0.1 to about 78%, wherein the perforations have an average diameter of between 0.1 and 1.5  $\mu\text{m}$ .

19. A process according to claim 18 wherein the unperforated layer is laminated to the perforated substrate.

20. A process according to claim 19 wherein an adhesive composition is applied by spray melt-coating onto one or both of the unperforated layer or the first surface of the substrate.

21. A process according to claim 20 wherein the adhesive composition comprises ethylene vinyl alcohol.

22. A process according to claim 18 wherein the unperforated layer is provided on the substrate by extrusion coating.

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